International comparisons of household energy efficiency

Introduction

To evaluate the energy efficiency of UK households it is useful to compare how well they perform relative to other countries. To this end, this article presents country-level indicators for the energy efficiency of European households from 2000 to 2017 based on data published by the ODYSSEE-MURE project.[1] It begins by examining how much energy is consumed by each country's domestic sector on an annual basis. It then shifts to a detailed assessment of the four main categories of domestic consumption: space heating, lighting & appliances, water heating and cooking. Finally, it concludes by highlighting that the technical efficiency of the UK's domestic sector has improved by 33 per cent over the past two decades.

When using indicators designed to make meaningful comparisons between countries, it is not possible to account for every factor that may vary from one country to the next. As a result, it is helpful to compare the UK to countries that possess similar characteristics in terms of climate, energy demands and economy, such as France and Germany, rather than to dissimilar countries, like Malta. Accordingly, the analysis presented below focuses on the fourteen countries that were members of the EU prior to 2004, plus Norway, to ensure that meaningful comparisons can be made with the UK.

All data presented in this article were taken from the ODYSSEE database. This database is part of the ODYSSEE-MURE project, which is a European Commission supported initiative that includes EU Member States, the UK and Norway. The majority of countries have data available from 2000 to 2017. However, in cases where data for 2017 were not available, the most recent data were used instead. If a country's name is not included in one of the provided charts, it is because they had yet to report any data for the indicator in question at the time of writing.

Household energy consumption

The UK's domestic sector consumed a total of 430 TWh in 2017.[2] This figure is equivalent to 28 per cent of the UK's final consumption in 2017, making the domestic sector the second largest consumer of energy after transport (40 per cent). Any variation in the energy efficiency of UK households is therefore likely to have a significant impact on the energy efficiency of the country as a whole.

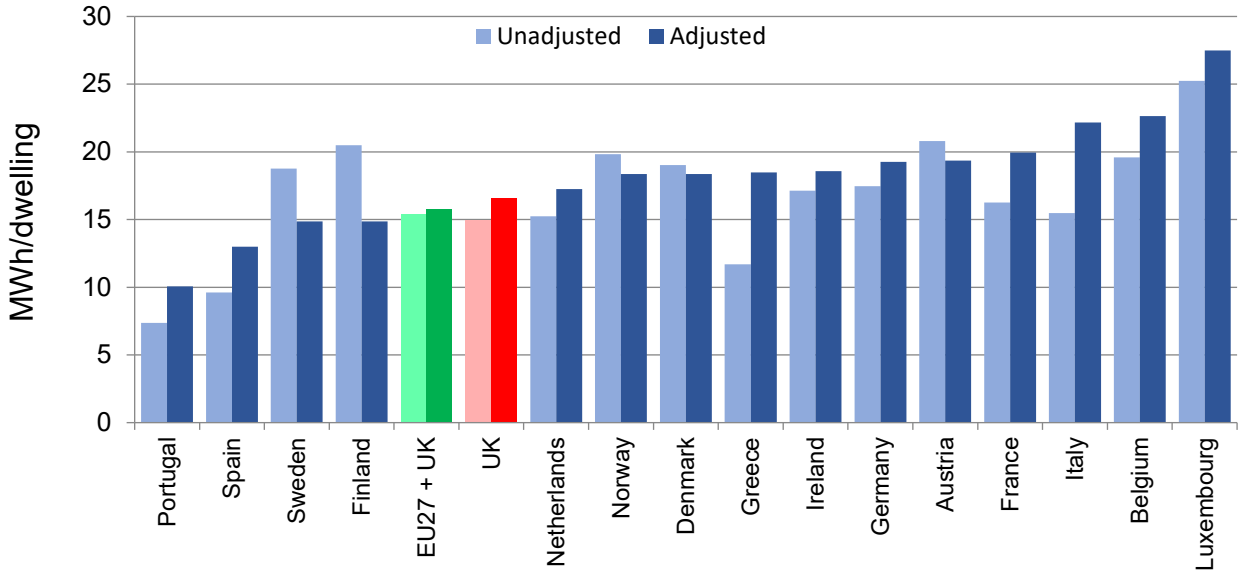
The main challenge when seeking to make international comparisons of energy efficiency is that all countries possess a unique combination of underlying characteristics. For example, a household that lives in a country with a cooler climate may use more energy to heat their home than a household living in a country with a warmer climate, even if their underlying heat source is more energy efficient. It is therefore advisable to use climate adjusted data to ensure that these comparisons are as meaningful as possible.

For the UK, there is little variation in its relative performance regardless of the chosen measure. The unadjusted data in Chart 1 show that it consumed an average of 14.9 MWh per dwelling in 2017, which places it slightly below the EU average of 15.4 MWh and fourth overall. And the adjusted data show that it consumed an average of 16.6 MWh per dwelling, which places it slightly above the EU average of 15.8 MWh and fifth overall. These data also show that the UK consumed 15 per cent less energy per household than Germany when adjusted for climate and 19 per cent less than France.

[1] Additional information on the ODYSSEE-MURE project can be found at: www.odyssee-mure.eu.

[2] All consumption data in ODYSSEE is reported on a Net Calorific Value (NCV) basis and hence differs from the main tables in UK statistical publications.

Chart 1: Domestic energy consumption per household in 2017, unadjusted and adjusted to EU average climate

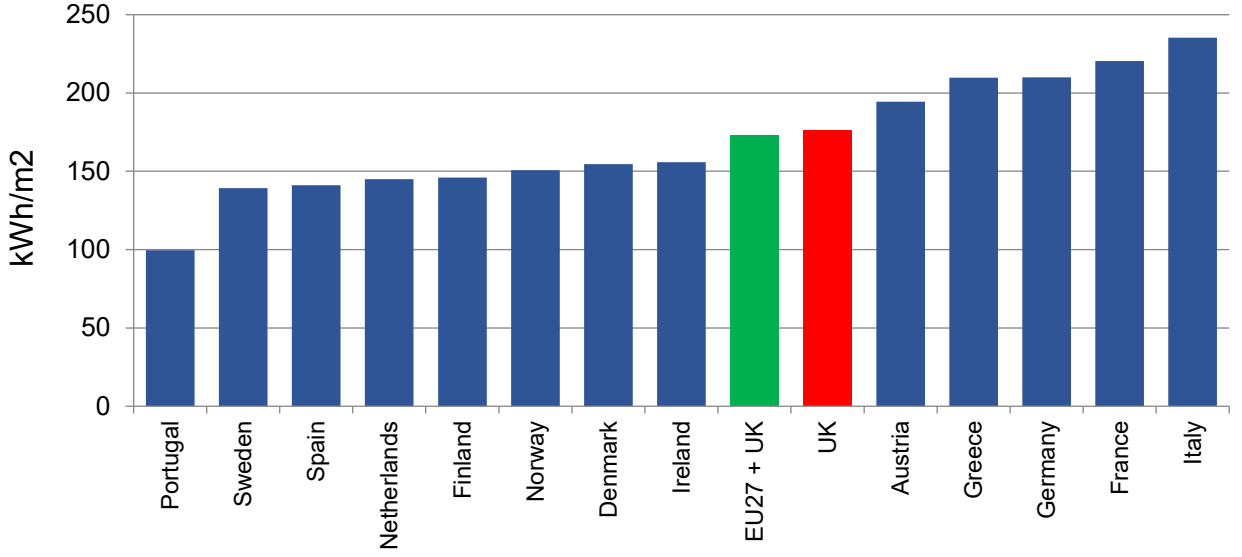


Source: ODYSSEE

An alternative method of evaluating the efficiency of a country's domestic sector is to use domestic energy consumption per m^2. This indicator helps to account for variation in the size of each country's dwellings, in the same way that the use of climate adjusted data helps to control for variation in external temperature. As a result, it provides a fairer comparison for space heating, but less so for appliance usage and in cases where the number of occupants per household varies. Overall though, a household that consumes less energy for a given unit of space is assumed to be more energy efficient than a household that consumes more energy for that same unit of space, even if their overall consumption is identical.

As shown in Chart 2, the UK's domestic sector consumes a relatively high amount of energy when measured on a per m^2 basis. With an average floor area of 94m^2, UK households consumed 176 kWh per m^2 in 2017, which places it slightly above the EU average of 173 kWh per m^2 and ninth overall. By contrast, the performance of some countries can be seen to improve when using this alternative indicator, with the Netherlands, Norway, Denmark and Ireland all shown to consume less energy than the UK when measured per m^2 rather than per dwelling.

Chart 2: Domestic energy consumption per m^2 in 2017, adjusted to EU average climate

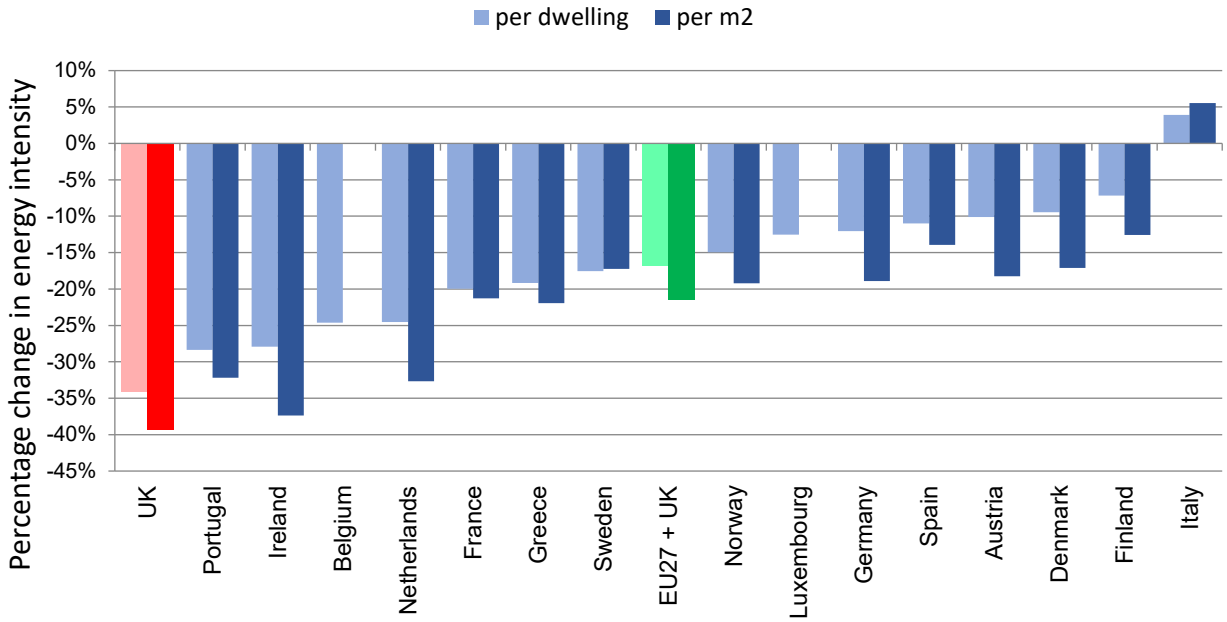


Source: ODYSSEE

The main reason for this difference is likely to be the smaller size of the UK's dwellings combined with its high rates of appliance ownership. The UK had the fifth smallest dwellings amongst the chosen sample in 2017, with an average floor area of only 94m^2. Its rate of appliance ownership was also the highest in the sample, with roughly five large appliances per household in 2017. By comparison, the country with the lowest level of consumption per m^2, Portugal, had an average dwelling size of 101m^2 and three large appliances per household. As a result, the energy intensity of each m^2 in the UK is higher than in Portugal, due to the need to distribute a larger amount of appliance consumption across a smaller amount of space. This phenomenon can also be observed for countries with similar size to ownership ratios as the UK, such as Germany and France, who see a similar shift in their relative ranking when measured on a per m^2 basis.

The data in Chart 3 show that the energy efficiency of the UK's domestic sector has improved by more than any other country in the sample from 2000 to 2017, regardless of which indicator is used to measure its progress. It experienced a 34 per cent improvement when measured on a per dwelling basis and a 39 per cent improvement when measured per m^2, despite its high ratio of appliances to floor space. These figures also indicate that the UK improved by roughly twice as much as the EU average over this time period, which experienced a 17 per cent improvement in consumption per dwelling and a 21 per cent improvement per m^2.

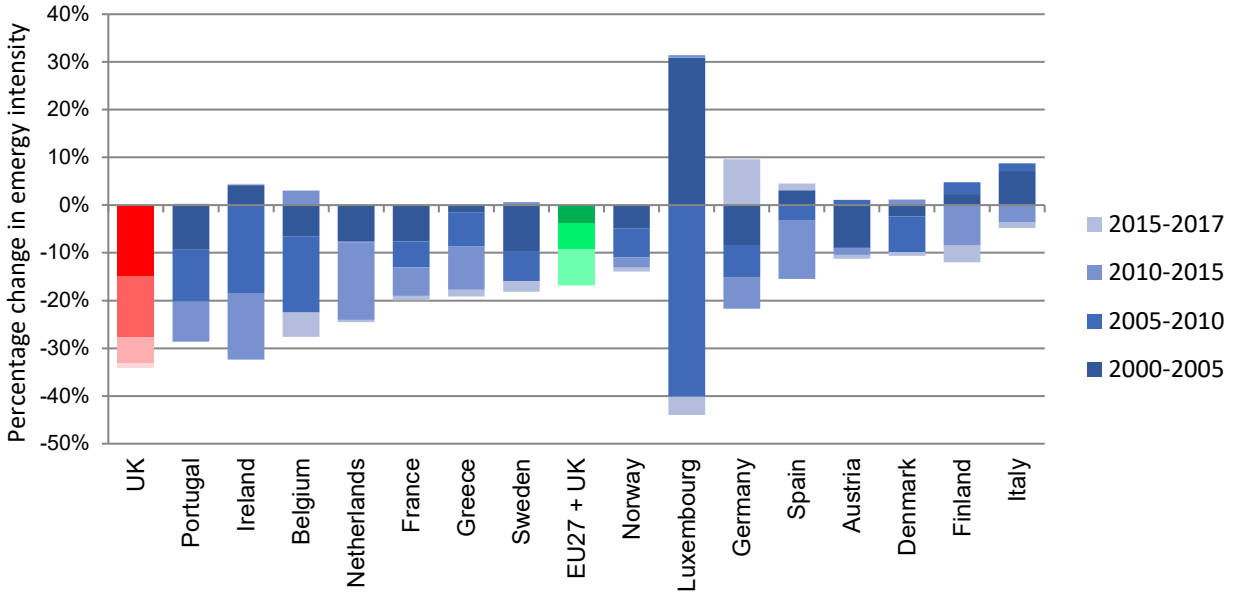
Chart 3: Percentage change in domestic consumption per dwelling and m^2, from 2000 to 2017, adjusted to EU average climate



Source: ODYSSEE

Having said that, it is worth noting that the UK's rate of improvement has not been consistent over time. As shown in Chart 4, the UK's consumption per dwelling improved by 15 per cent from 2000-2005 and then a further 13 per cent from 2005-2010, compared to EU averages of 4 per cent and 6 per cent. Its progress then slowed to a further 6 per cent reduction from 2010-2015 followed by an additional 1 per cent from 2015-2017, compared to EU averages of 7 per cent and no change. These data suggest that the UK is not alone in terms of its slowing rate of progress, which has been mirrored across the EU as a whole. However, they also suggest that the most significant improvements to the UK's household energy efficiency were achieved in the first decade of the millennium, with less improvement made in recent years.

Chart 4: Cumulative percentage change in domestic consumption per dwelling relative to the baseline year of 2000, by time period, adjusted to EU average climate



Source: ODYSSEE

Space heating, lighting & appliances, water heating and cooking

The previous section showed that the UK's domestic sector is relatively efficient compared with other European countries, in addition to being amongst the most improved. This section shows that the majority of the UK's progress in this area can be linked to improvements in the energy efficiency of space heating, as well as more modest gains in terms of lighting & appliances, water heating and cooking.

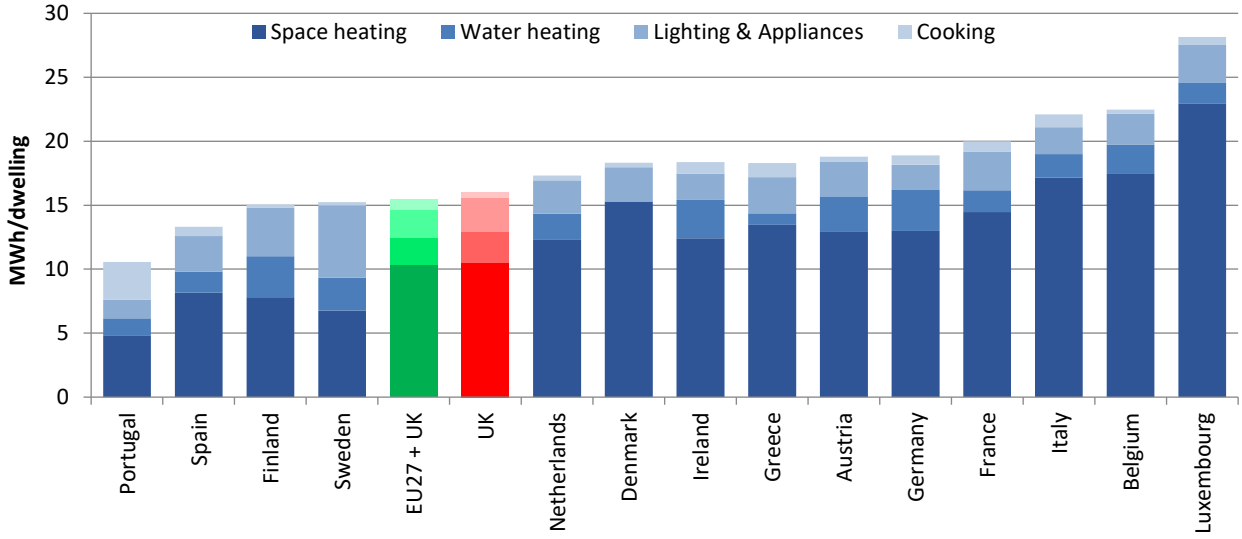
As shown in Chart 5, the largest component of household energy consumption in all fifteen countries is space heating. It accounts for 67 per cent of average national consumption, with the remainder consisting of lighting & appliances at 14 per cent, water heating at 13 per cent and cooking at 5 per cent.[3] For the UK, these data reveal a similar pattern, with space heating consuming 65 per cent, lighting & appliances 17 per cent, water heating 15 per cent and cooking 3 per cent. They also show that the UK uses less energy than France and Germany for space heating, that it falls in-between these two countries for both lighting & appliances and water heating, and that it consumes the least amount of energy for cooking.

Due to the large share of space heating in the UK's consumption profile, any reduction in the consumption of this single category is likely to have a considerable effect on the consumption of the domestic sector as a whole.[4] It is therefore important to note that the UK made the third largest reduction in this end use from 2000 to 2017, with a 31 per cent decrease in consumption per dwelling.

[3] The data for water heating were not available in a climate adjusted form so the provided totals are likely to be slightly higher for colder countries than they are for warmer countries. A fifth category of domestic end usage – air cooling – has also been excluded from Chart 5, due to its relatively small share of overall consumption in each country (i.e. no larger than 0.67 per cent).

[4] Due to missing data, all calculations involving the unit consumption of space heating in the UK use the total from 2002 for both 2001 and 2000.

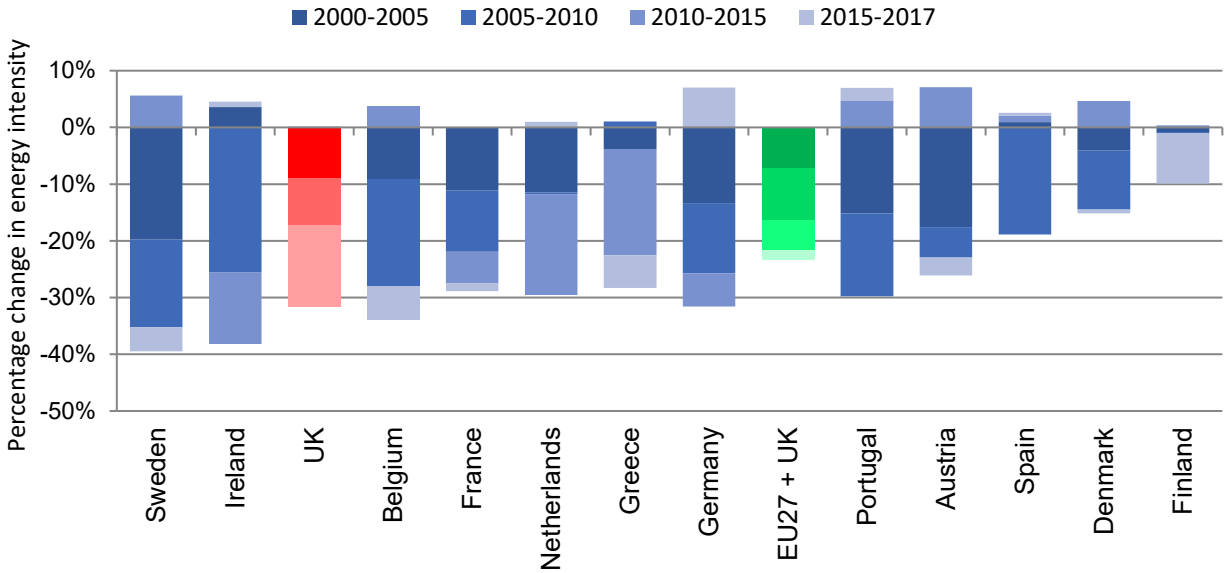
Chart 5: Unit consumption per dwelling for 2017, by end usage, with space heating usage adjusted to EU average climate



Source: ODYSSEE

However, as shown in Chart 6, the consumption of space heating in the UK has not decreased at a consistent rate over time. After decreasing by roughly 9 per cent from 2000-2005 and then a further 8 per cent from 2005-2010, it decreased by an additional 14 per cent from 2010-2015 and then increased by 0.2 per cent from 2015-2017. Although this last figure is close to the EU average, which decreased by 1.7 per cent over this final two-year period, it suggests that the UK's progress in this area has stalled in recent years.

Chart 6: Cumulative percentage change in unit consumption of space heating per dwelling relative to the baseline year of 2000, by time period, adjusted to EU average climate



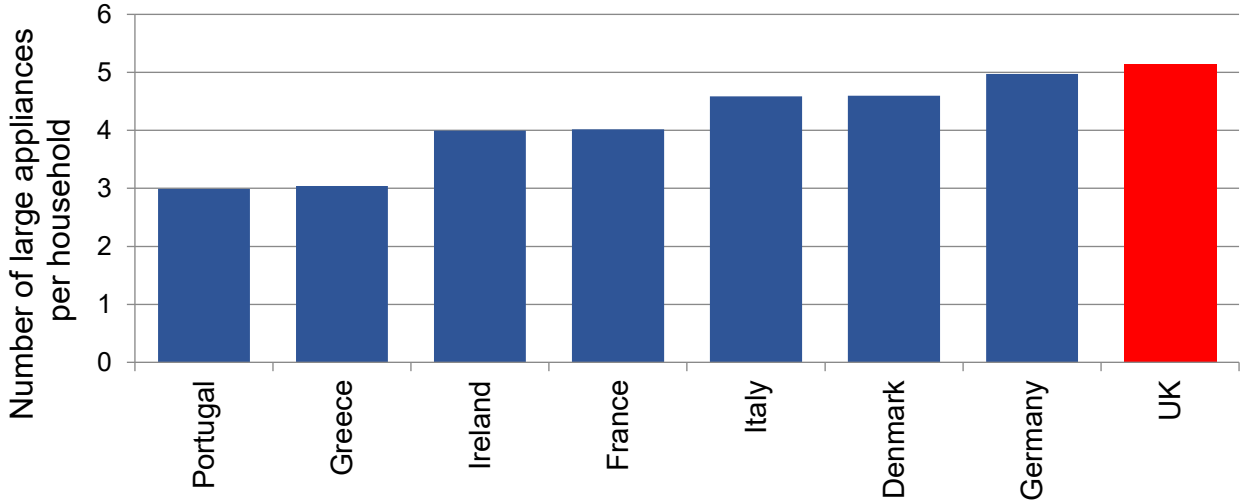
Source: ODYSSEE

Although their absolute impact has not been as large, the amount of energy consumed for other end uses in the UK has also decreased over the past two decades. The largest reduction in consumption per dwelling was for water heating (32 per cent), followed closely by cooking (30 per cent). However, the relatively small share of domestic consumption for cooking, which stood at only 0.4 MWh per dwelling in 2017, means that the overall impact of this improvement is likely to have been limited.

By contrast, the UK experienced an 8 per cent reduction in energy consumption for lighting & appliances from 2010-2017, which accounted for a more substantial 2.7 MWh per household in 2017. The size of this reduction was larger than the EU average for this time period, which stood at 3 per cent, as well as relative to the 4 per cent improvement in Germany and the 13 per cent decline in France.

To identify the potential source of this reduction, it is useful to start by looking at how many appliances are owned by a typical UK household. As shown in Chart 7, the average household in the UK possessed slightly more than five large appliances in 2017,[5] which is around the same as ownership levels in Germany. When broken down further, these data show that the average UK household owned 2.4 televisions, 1.1 refrigerators (including fridge-freezers), 0.8 washing machines, 0.5 freezers and 0.4 dishwashers in 2017.

Chart 7: Average number of large appliances per household in 2017



Source: ODYSSEE

These kinds of details are helpful because they can be used to understand why appliance-related consumption in the UK declined from 2000 to 2017. For example, the average dishwasher in the UK used approximately 288 kWh per year in 2017, which was nearly triple the amount of energy required to power an average television.[6] However, due to the disparity in ownership levels between these two types of appliances, the total energy consumed by televisions was roughly double the amount of energy consumed by dishwashers. As a result, improvements in the energy efficiency of certain types of appliances will end up having a greater impact on household consumption than others.

As shown in Chart 8, the energy efficiency of the UK's freezer stock (excluding fridge-freezers) improved by more than any other appliance over this time period, with a 52 per cent decrease in unit consumption from 2000 to 2017.[7] However, due to the relatively low rates of freezer ownership across the UK, this large decrease at the unit level actually resulted in the lowest substantive impact

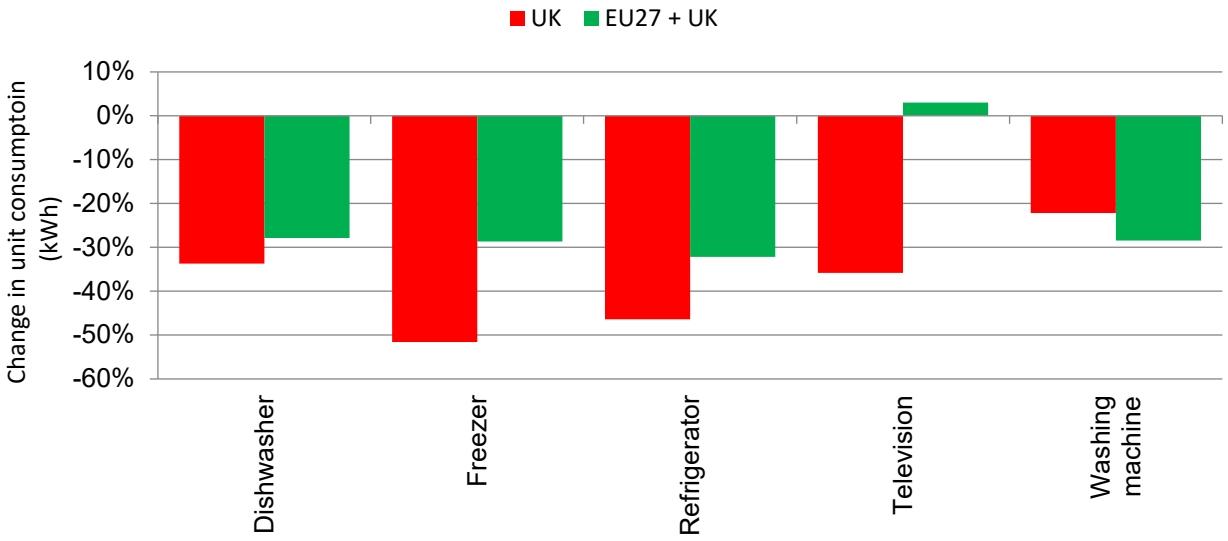
[5] Although this category of appliances is not exhaustive, with the definition of a 'large' appliance restricted to freezers, refrigerators, televisions, dishwashers and washing machines, it accounts for the majority of appliance-related consumption in European households.

[6] The consumption figures for televisions are based on the average power of the television stock as a whole, rather than a specific type of size or type of television, so it is likely to underestimate the usage of some televisions and overestimate the usage of others.

[7] When calculating unit consumption figures, ODYSSEE used a mixture of theoretical assumptions about each country's appliance stock rather than measurements of energy usage. For example, the energy efficiency of dishwashers and washing machines was estimated by multiplying the average electricity consumption per cycle for each appliance by a set number of cycles per year. See their methodology note for additional details: www.indicators.odyssee-mure.eu/odex-indicators-database-definition.pdf.

of all five types of appliance. By contrast, the 46 per cent improvement in the efficiency of refrigerators had the largest substantive effect, due to a combination of high ownership rates and high unit consumption. It is also worth noting that the energy efficiency of the UK's appliances improved by more than the EU average in all five categories, as well as relative to Germany in every category aside from washing machines.

Chart 8: Percentage change in unit consumption of large household appliances, from 2000 to 2017



Source: ODYSSEE

Technical energy efficiency

The previous section demonstrated that the efficiency gains made by the UK's domestic sector have primarily been driven by improvements to the energy efficiency of its space heating, water heating and large appliances. This section provides further evidence for this relationship by highlighting how much the modelled technical efficiency of UK households has improved over the past two decades.

A country is considered to be more technically efficient than another when it is able to produce more of a given output when using an equal amount of energy. A more technically efficient household should require less energy to heat to the same temperature and be able to run its appliances for longer than a less efficient household whilst consuming the same amount of power.

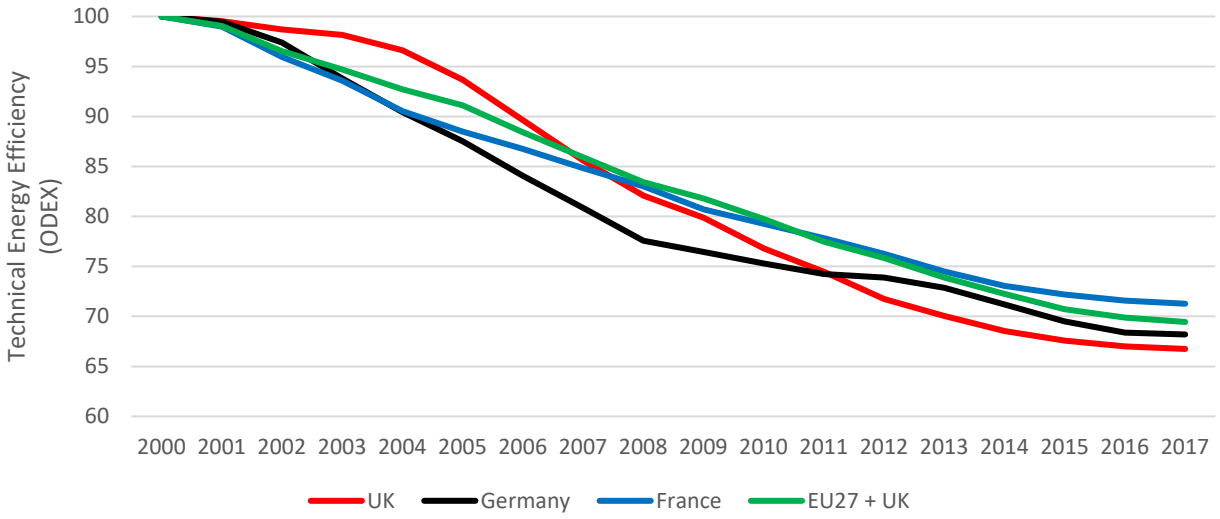
To measure technical efficiency, the ODYSSEE-MURE project developed a model that combines the efficiency gains made by four types of domestic consumption: space heating, water heating, cooking and large appliances. After weighting the gains in each category relative to their share of overall consumption, the model makes additional calculations to account for the effects of non-technical variation in consumption, such as the energy efficiency of each country's building stock.[8] The end result is the creation of a technical energy efficiency index (ODEX) consisting of a single value per country per year, with values above 100 indicating a net decrease in energy efficiency since the baseline year of 2000 and values below 100 indicating a net increase in energy efficiency.

As shown in Chart 9, the technical energy efficiency of the UK's domestic sector improved by roughly 33 per cent from 2000 to 2017. The largest change occurred from 2004 to 2014, which accounted for 85 per cent of the UK's overall improvement. The UK's experience also slightly exceeded that of its European neighbours over the whole time period, with the 33 per cent improvement in the UK

[8] For a more detailed explanation of the steps used to calculate ODEX, see the 'Energy Efficiency index ODEX' section of ODYSSEE's methodology note: www.indicators.odyssee-mure.eu/odex-indicators-database-definition.pdf.

roughly equivalent to the 32 per cent improvement in Germany and the 29 per cent improvement in France.

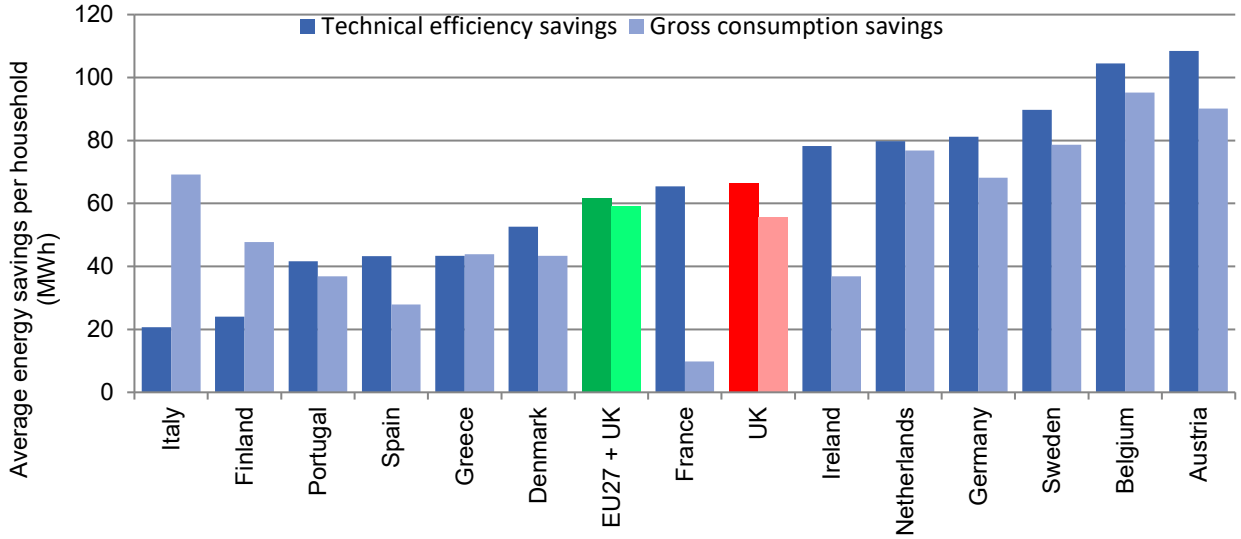
Chart 9: Technical energy efficiency index (ODEX) of the domestic sector, from 2000 to 2017



Source: ODYSSEE

Due to the abstract nature of ODEX scores, it can be difficult to understand the substantive impact of these improvements without a more tangible point of reference. The data in Chart 10 show that the UK made cumulative technical efficiency savings of 66.5 MWh per household from 2000 to 2017,[9] compared to average annual household consumption of 16.6 MWh in 2017 when adjusted for climate.

Chart 10: Cumulative energy savings per household, from 2000 to 2017, adjusted to EU average climate



Source: ODYSSEE

[9] This figure was calculated by first estimating how much energy the UK's domestic sector would have consumed if it had not made any efficiency gains since 2000 and then subtracting the amount of energy that the domestic sector actually consumed from this total. The resulting figure was then divided by the number of permanently occupied dwellings in the UK by the end of 2017.

Conclusion

The purpose of this article has been to evaluate the energy efficiency of UK households by comparing their performance relative to other countries. To ensure that a meaningful comparison could be made, the UK's performance was assessed relative to a group of similar European countries using energy efficiency indicators published by the ODYSSEE-MURE data project.

The main conclusion of this exercise is that the UK's domestic sector is relatively efficient by European standards. It is ranked as the fifth most efficient country in the sample if assessed on a per household basis and the ninth most efficient if assessed on a per m^2 basis, in addition to experiencing the largest overall improvement from 2000 to 2017. However, this article has also shown that the most significant improvements to household energy efficiency in the UK were achieved during the first decade of the millennium, with less improvement made in recent years.

To understand why the UK's energy efficiency has improved, this article also disaggregated domestic energy consumption into its four main end uses: space heating, lighting & appliances, water heating and cooking. In doing so, it demonstrated that the majority of the UK's improvement can be linked to the increased efficiency of space heating, which constitutes the single largest consumption category for UK households. It also showed that there have been improvements to the energy efficiency of water heating, cooking and large appliances over time. As a result, the technical efficiency of the UK's domestic sector has improved by 33 per cent over the past two decades, meaning that UK households now use one third less energy to produce the same level of output as they did in 2000.

For further information on International Energy Efficiency Statistics, please contact:

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